Bond as an astronomer, said that he saw around him so many of his friends and neighbors, that it was hardly necessary to speak of his personal qualities as witnessed by them in private intercourse. To them, indeed, it is not necessary. They anticipate at once all that can be said on this point. But, Sir, Mr. Bond was for so long a time obliged to consecrate whatever of time and health his physical infirmity left at his disposal to the study of the heavens, that his earthly relations were comparatively contracted; and many who have been nigh dwellers have had to regret that they could not, with a true regard for him, seek to be neighbors. I happen to be one of the few persons present who began to know him, in social and domestic life, long before he came to the University; and we know, that, to the last, in his domestic and social relations he manifested the spirit of the heaven of heavens, — there is but one word for it, — love. It was his very nature.

"President Quincy has informed us how the professional astronomer was superinduced on the devoted father of a family. Mr. Bond was also the staff of his own venerable father, to be again, in his turn, blessed during his public scientific career with the support — the co-operation of mind, heart, and hand — of one who has been to him at the same time a son and as a brother. Allusion has been made, Sir, to the beautiful blending of these relations in the case of the deceased friend whom the Academy has just commemorated. The parallel occurred to me when the parties were all living; and I trust that the mention of it now is not out of keeping in a meeting like this. I heartily second the resolutions."

The resolutions were then unanimously adopted.

Four hundred and sixty-first meeting.

February 22, 1859. — SUPPLEMENTARY MEETING.

The PRESIDENT in the chair.

Professor Gray resumed the subject of his communication to the meeting on January 11, upon the distribution of plants in the northern temperate zone, and especially in North America and Eastern Asia, and undertook to indicate some of the vicissitudes to which our extant vegetation must have been exposed in earlier times, and which must have influenced the geographical distribution of the species.

He remarked that, for obvious reasons, the remains of plants are not so likely to be found in recent terrestrial formations, as the bones of animals; but when they do occur, they furnish most important data. Researches into vegetable fossils of the tertiary and quaternary formations have recently been commenced in this country by Mr. Leo Lesquereux, who has already shown, in the very beginning of these investigations, that some of our species of plants were in existence anterior to the drift or glacial epoch, and even in the later tertiary period. For instance, in the chalky banks of the Mississippi River, near Columbus, Kentucky, regarded by Mr. Lesquereux as anterior to the drift, this accurate botanist had identified fossilized leaves of our Live-Oak, Honey-Locust, Pecan, Planer-tree, Chinquapin Chestnut, and *Prinos lucidus*, besides those of an Elm and of a *Ceanothus*, which were only doubtfully referable to existing species. The position of the strata bearing these fossil leaves had been indicated by Professor D. D. Owen "as about one hundred and twenty feet lower than the ferrugineous sand in which the bones of the *Megalonyx Jeffersonii* were found"; so that if not anterior, they must have been immediately subsequent to the glacial period; — most likely the latter, since all the vegetable remains of this deposit, which were in a determinable condition, were either positively or probably referred to existing species of the North American flora, although most of them now inhabited a region a few degrees farther south. Again, in a deposit, certainly older than the drift, near Somerville, Tennessee, which Mr. Lesquereux regarded as belonging to the lower or middle pliocene, among fossil leaves all apparently referable to genera of the present flora, two fifths of the species were identified by Mr. Lesquereux with existing species; those of which the identification was undoubted, viz. *Persea Carolinensis*, *Prunus Caroliniana*, and *Quercus myrtifolia*, now belonging to the warm sea-coast and islands of the Southern States.

Professor Gray remarked that this coincided with other

evidence, which conspired to render it in the highest degree probable, as he thought, that at least a considerable portion of our temperate flora was in existence in the early post-tertiary, and even in the later tertiary times. Also, that this early temperate flora then ranged much farther north than now. This he thought clear, both from the species identified in these deposits, and especially from the character of the land animals which in those days roamed over the plains of the Nebraska, consisting of Camels, Horses, an Elephant, a Mastodon, a Rhinoceros, &c.; these herbivorous animals most probably feeding in great part upon herbage like that of the present period, since herbaceous plants and grasses are likely to be more ancient than trees. And, since these animals must have had a truly warm-temperate climate, Professor Gray would positively infer that, in lat. 40° – 43°, they were not living anywhere near the northern limit of the temperate flora; so that the temperate flora, which now crosses the sixtieth parallel in Western Europe, must have then extended to at least as high latitudes in Western North America; and this would make the temperate floras of North America and of Northeastern Asia essentially conterminous, and therefore commingle a certain number of species.

Subsequently, the glacial epoch, coming slowly on, did not destroy the species, or at least did not destroy those species which Mr. Lesquereux has identified with existing ones, so that the same may be inferred of similar species. Those which did survive through a period which brought an arctic climate down to the northern part of the Southern United States, it appeared certain to Professor Gray, must have been pushed on still farther south, and between them and the ice there must have been a band of cold-temperate and of arctic vegetation, perhaps as broad as that now interposed between Live-Oaks, Chinquapin Chestnuts, or Pecan-trees, and the present ice. The existence at that period of an arctic flora, of species identical with the present, was demonstrated by the arctic species which, retreating up our

mountains as the climate gradually grew milder, still exist scantily upon the highest peaks of the Alleghanies, and in greater numbers upon the cooler mountain-summits of New England and New York.

As the ice receded northward at the close of the glacial period, the temperate flora would naturally follow it; and Professor Gray insisted, as a most important point in the present discussion, that the temperate vegetation must have again advanced, after the glacial epoch, much farther north, and especially northwest, than it now does; so far north, indeed, that the temperate floras of North America and of Eastern Asia — before conterminous, and then most widely separated — must have again become conterminous. However it may have been in the ante-glacial period, — although it appears certain that some, and probable that many, of our species of plants then existed, — Professor Gray thought it could not be doubted that most of our present species were in existence immediately after the glacial period, and therefore liable to interchange with Eastern Asia at a time when the temperate floras of the two regions were contiguous.

The evidence of such contiguity during what Professor Dana terms the *fluvial epoch*, which succeeded the glacial, Professor Gray remarked, was that a milder climate than the present then supervened, — perhaps not so much higher in the mean temperature of the year at the North, as more equable, — a more oceanic climate, such as would naturally result from the extensive submergence of northern, or at least of northeastern land, when the sea stood five hundred feet above its present level in the basin of the St. Lawrence, and our great alluvial plains, from fifty to three hundred feet above the present bed of the rivers, were flooded. Professor Gray alluded to the character of the herbivorous animals of that period, and their high northern range, as demonstrating that our temperate flora then reached northward far beyond the arctic circle; for that was the era of the *Megatherium*, *Megalonyx*, *Mylodon*, *Mastodon*, a *Dicotyles*, a wild horse,

&c. in the United States; when the *Elephas Americanus* ranged north to Canada, and the Siberian *Elephas primigenius* from Canada to the Arctic Sea, as well as in Europe and Asia from lat. 40° to the shores of the Arctic Ocean, — in the Old World accompanied by a *Rhinoceros*, which in Siberia ranged as far north as the Elephant. Taking this as proof that the temperate floras on both sides extended fully up to Behring's Straits, — if, indeed, these straits then existed, — Professor Gray was unable to suppose that species of plants did not come or go when the Siberian Elephant did.

This warm or mild period was followed by the *terrace epoch*, as Dana terms it, — a time of transition towards the present condition, bringing the northern part of this continent up to its present level and down to its present cool temperature, so giving to the arctic flora its present extent, and again separating the temperate floras of the New and of the Old World to the extent they are now separated.

Professor Gray observed, that he could not appreciate the objection that the admission of such vicissitudes militated against the idea of a plan in creation, and in "the adaptation of organic types to similar corresponding physical features," unless the objection goes to the extreme of implying that the present state of things so strictly represents the primitive condition as to exclude second causes, and to deny that physical influences, known to have been in operation, should have produced their natural effects in former times as well as now. Looking at the long and eventful history of vegetable species, Professor Gray was not inclined to think that the *Eriocaulon septangulare* of our Atlantic border was separately created also in the Isle of Skye and a few of the neighboring Hebrides, and in a local station on the western coast of Ireland, while it occurs nowhere else in the Old World, and has not a single generic or ordinal representative in Europe, — nor that the Ginseng was created in three widely-separated parts of the world, viz. in Eastern North America, in Japan and Mantchuria, and

in Nepaul, — any more than that patches of Alpine vegetation, wholly of Labradorian species, were separately created on Mount Katahdin in Maine, the White Mountains of New Hampshire, and a few summits of the Green Mountains and Adirondacks.

As respects the vegetation of former epochs, so far was Professor Gray from conceding "that the present distribution [of *plants*] was linked with that of earlier periods in a manner which excluded the assumption of extensive migrations, or of a shifting of the flora from one area to another," that he was, on the contrary, struck with the remarkable dissimilarity between the early tertiary and the more ancient floras of Europe and America and that now existing; for example, the miocene flora of the coast of Oregon being very like that of Switzerland of the same period, and in both a tropical flora of predominant Australasian types; the eocene flora of at least some parts of Europe being prominently Australian; the flora of Europe, even since the creation of some existing species, possessing numerous North American types of which there are now no representatives whatever on that continent, &c.

In conclusion Professor Gray remarked, that, when we speculate about the *origin* of species, we launch out beyond the region of induction, and have only analogies or probabilities to guide us, which we have to weigh one against another as well as we can. And he deemed it very important to the progress of science that different investigators should start from independent and opposite preconceptions or lines of thought. His preconception was that of the local origination of species; not origination in single individuals or single pairs, — which might or might not be the case in different species. The improbability of single origin appeared to him to be great in the lower grades of animals; the probability of it greater and greater as we rise in the scale of being. But the local origination of each species appeared to him not only the natural hypothesis to begin with, as he had before

remarked, but also the one which, on applying it to the case in hand, he thought best adapted to explain the actual distribution of plants. Although not inclined to defer too much to *a priori* reasoning, he thought it was suggested by philosophical considerations, as well as by the induction of observations; being a natural inference from Maupertuis's principle of *least action*, viz. "that it is inconsistent with our idea of Divine Wisdom to suppose that God would use more power than was necessary to accomplish a given end." According to Professor Peirce, this principle is strictly verified in all the mechanical arrangements of the universe; so that we cannot but think it applicable to the organic world also; — in which there would appear to be a vast waste of power, if, in the case of beings endowed with such immense multiplying power as plants, as many individuals were created *ab initio* as there were ever subsequently to be.

The discussion was continued by Professor Agassiz, who remarked that Professor Gray had fairly represented his view of the origin of animals. Botanists, he said, have considered the distribution of plants mainly in connection with the influence of physical agents, whereas zoölogists had regarded the distribution of animals from a palæontological point of view, and from this latter point of view he had himself been led to the opinion that animals were primarily distributed about as they are at the present time.

Professor Agassiz argued that climate has very little to do with the distribution or specific characters of animals, from the facts observable at the present time. Near the poles, he remarked, the conditions of existence are quite uniform, and in the tropics they are the same so far as climate is concerned. In the arctic regions we find many animals absolutely identical in both hemispheres, and many very closely related to each other; in the regions of the tropics, on the other hand, there is no similarity in the animal life of the two hemispheres, although the climate is the same. It is evident, therefore, that the peculiar characters of the Faunæ of these regions cannot

be ascribed to the influence of climate. In passing from the arctic to the tropical regions, the uniformity of animal life in the former passes gradually into the extreme diversity of that in the latter, and in the causes of difference in the tropics Professor Agassiz said he saw the reasons for all differences, wherever observed. How far back, he asked, does this state of things go? In the tertiary times of Australia the peculiar types of animal life existed which give at the present time the distinctive character to its Fauna, and the same is true of the tertiary Fauna of South America. These facts, and others like them, have led him to believe that animals were primarily distributed over the surface according to a plan hardly intelligible as yet to us, but independent of climatic influences. This plan he believed included the preparation for the earth's surface and the various external conditions of their existence for its inhabitants, before they were created, very much as a householder lays his foundation and builds the superstructure and arranges the furniture of the interior for his residence before occupying it.

Professor Gray had quoted a number of plants as identical in the tertiary and the present period. Des Hayes and Lyell had admitted the same with regard to the animals of these periods. Professor Agassiz said he had doubted the fact in the case of animals, and had therefore early in his scientific career collected many specimens to settle the question, and in every instance where he had sufficient materials he had found that the species of the two epochs supposed to be identical by Des Hayes and Lyell were in reality distinct, although closely allied species. He was therefore inclined to ask whether it might not be possible that the same is the case with the plants of the tertiary period and those of the present day? He could not but believe that, if Professor Gray were to exercise the same critical judgment upon the fossil Flora which he does with reference to the existing Flora, he would find differences between the species of the two epochs similar to those found in the animal world. There is not, at the

present time, he added, an equal knowledge of all the facts in Botany and Zoölogy.

Professor Agassiz referred to his former statements with regard to the similarity of the turtles of Eastern Asia and Eastern North America, and of those of Western North America and Europe, and showed how these differences seemed to be related to the geological age of these respective regions, and were at variance with the supposition of an interchange of species, such as Professor Gray believes to have occurred in the vegetable world: in the instance quoted, there is an alternation of two fields of animal life of entirely different types. In conclusion Professor Agassiz reiterated his statement, that he believed that the present races of animals were originally created on the earth in about the same proportionate numbers as they are found to have at the present time, and in about the same localities as those they now occupy.

Professor Peirce spoke of the changes of temperature which had been referred to as having influenced the distribution of plants and animals, and said he thought it an important inquiry, to discover how such a change could have taken place. With regard to the supposed cooling down of the earth, he showed that the conditions under which it could have taken place were inconsistent with the existence of plants and animals on its surface, and the time when it must have occurred must have been long before they were created. The sun's temperature, he said, might have undergone changes from time to time, but there was no proof that such had been the case; and if it had been so, the effect on the earth would have been uniform. The change of the area of the land, and the elevation of portions of the earth's surface, would account for the glacial period, and climatic and meteorological changes might have resulted from changes in the amount of the earth's atmosphere.